a place of mind

EXPANDING CHERRY PRODUCTION IN BRITISH COLUMBIA UNDER CLIMATE CHANGE

Certified Organic Associations of BC
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Team Members

- UBC Okanagan:
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  - PDF: Dr. Tanja Voegel
  - MSc students: Paige Munroe, Tirhas Gebretsadikan
  - Collaborators:
  - Drs. Denise Neilsen and Tom Forge, AAFC Summerland Research and Development Centre

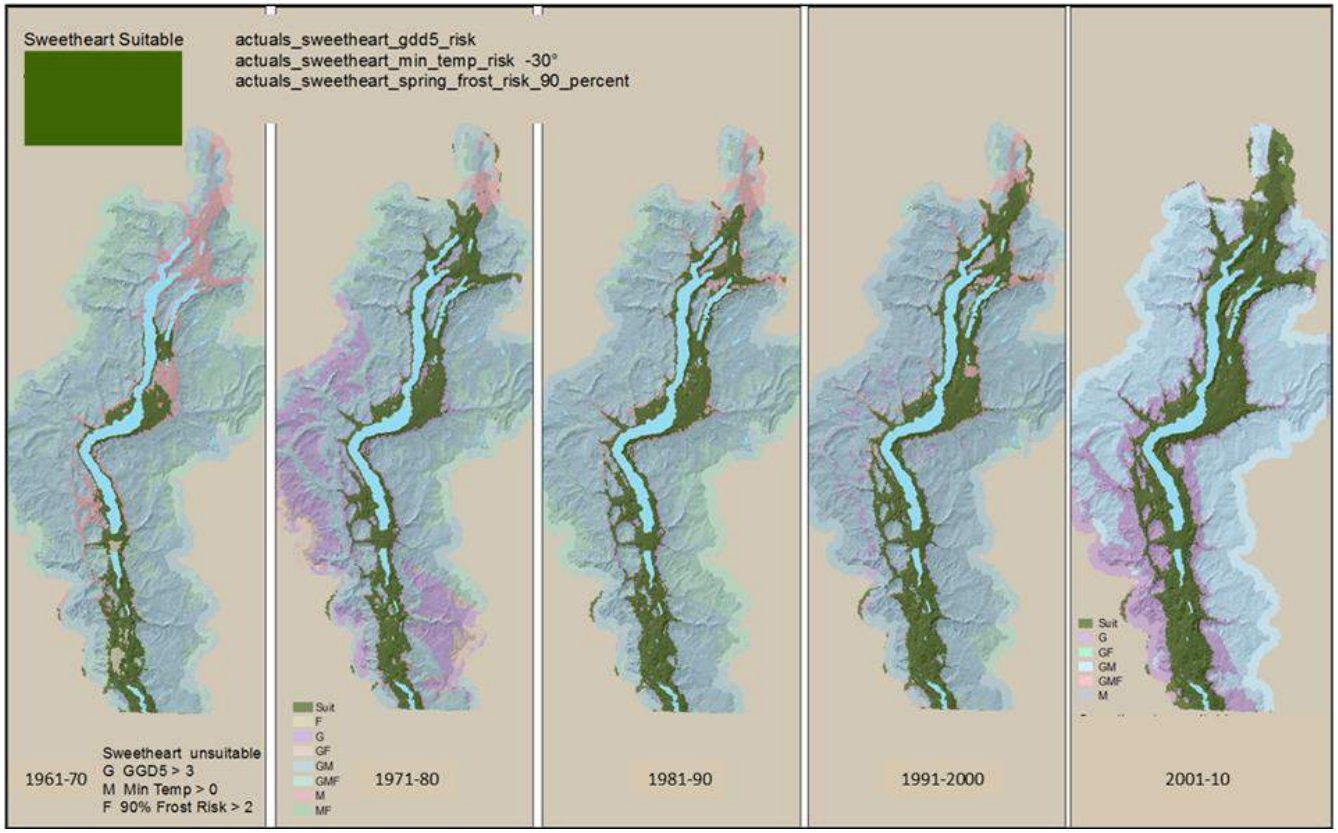
Background

Importance of Sweet Cherry Production in BC

- In 2015 BC produced about 15,500 metric tonnes of sweet cherry with a farm gate value of $55.8 million, a 22% increase from 2014[1]
- This represents >95% of the total cherry production in Canada[1]
- Cherries are now BC's largest tree fruit export, increasing to $92 million in 2015[1]
- Access to new markets – e.g. China, Hong Kong, Taiwan, UK, USA

[1]https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/statistics/industry-and-sector-profiles/year-in-review/bcagrifood_yearinreview_2015.pdf

Effect of Climate Change on Areas Suitable for Cherry Production in the Okanagan



Crop suitability modelling for Sweetheart cherry in the Okanagan region over the past 50 years. Dark green areas are climatically suitable.

Developed using the following combined criteria: chance of 90% blossom kill in spring, growing season length and absolute minimum winter temperature

(Denise Neilsen and Scott Smith, unpublished data).

Challenges with Climate Change

- Maintaining soil health
  - Restrictions on use of fumigants
  - Replant disease common in established orchards in south Okanagan
    - Alternatives to fumigation needed
      - Organic amendments
        - Compost
        - Mulch
- Limited water availability
  - Increased water-use efficiency needed
    - Mulching
    - Drip or micro-sprinkler irrigation
    - Timing and frequency of watering

M. Thurston, BC Tree Fruits Coop.

T. Gebretsadikan, UBCO

What is Replant Disease?

- Common to all major tree fruit growing regions in the world
- Poor growth, establishment or death of young trees planted into orchards where fruit trees of the same or related species have been grown previously
  - Delay in initial fruit production
  - Decreased fruit quality and yield

- Causes
  - Vary with geographic region and orchard
  - Soil-borne organisms implicated
    - Root-lesion nematodes –*Pratylenchus penetrans* in the Okanagan
    - Soil pathogenic fungi – *Rhizoctonia, Fusarium, Pythium, Phytophthora, Cylindrocarpon* spp.
  - Abiotic factors can exacerbate microbial effects
    - Low P availability
    - Non-optimal pH
    - Phytotoxins
    - Poor soil structure or drainage
  - Soil pasteurization or fumigation improves plant growth

http://extension.wsu.edu/chelan-douglas/agriculture/treefruit/horticulture/plantingneworchards/soilcharacteristics/orchardsoilfumigation/

Long-Term Objective

To facilitate expansion of cherry production in the Okanagan Valley under current and projected climate conditions while optimizing soil health and water use efficiency

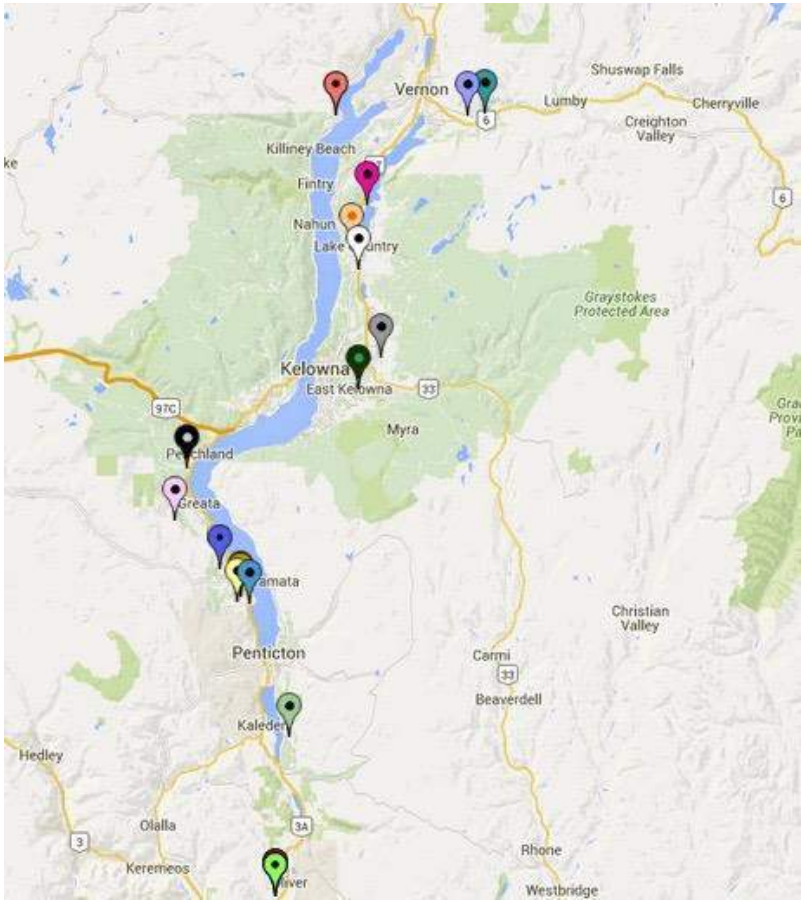
Preparing for mulch application at the Coldstream site

Preparing for compost application at the Lavington site

Short-term Objectives

To enhance the natural biological buffering capacity of soils in cherry orchards newly planted on non-fumigated soils

- Determine if native soil microbial populations enhance or restrict cherry growth
  - Greenhouse bioassays of old and new orchard soils from 18 sites from south to north Okanagan
  - Sterilized and non-sterilized treatments
  - Soil physico-chemical properties determined
  - Cherry explant growth measured



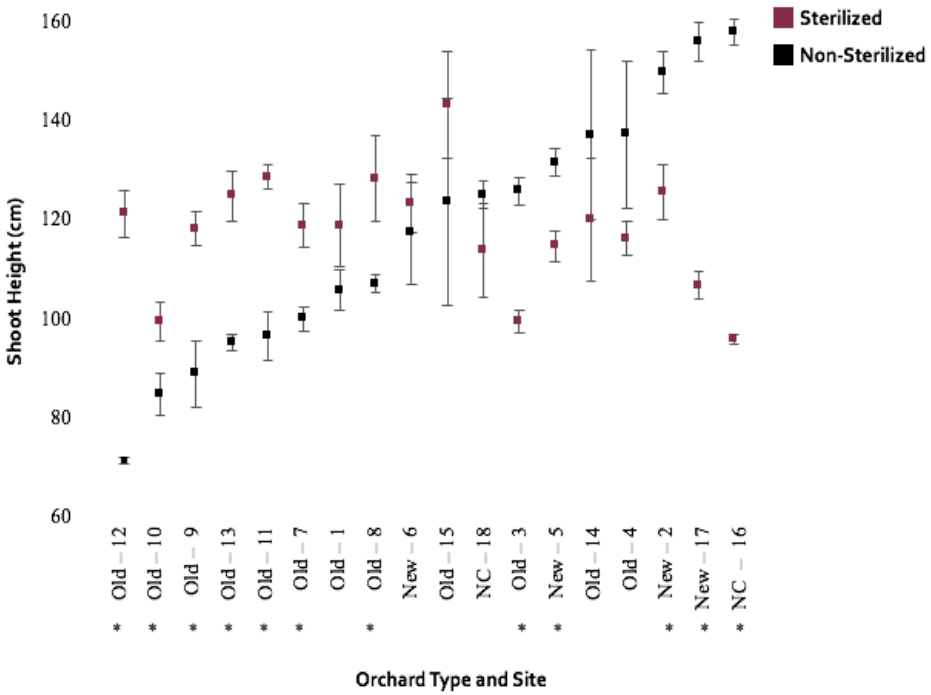
Soil Properties of the 18 sites

Site	Lati-tude (º)	Elev-vation (m)	CEC (S/m)	pH	C:N	OC (%)	TN (%)	P (mg/kg)	K (mg/kg)
New (n=6)	50.0	681	16.4	6.1	10.1	3.2	0.3	134	431
Old (n=12)	49.7	444	14.4	6.8	9.7	2.3	0.2	100	378

- New sites on average:
  - were at higher latitude and elevation
  - had higher cation exchange capacity, C:N ratio, organic carbon, P and K
  - had lower pH

Plant Growth and Soil Microbial Activity

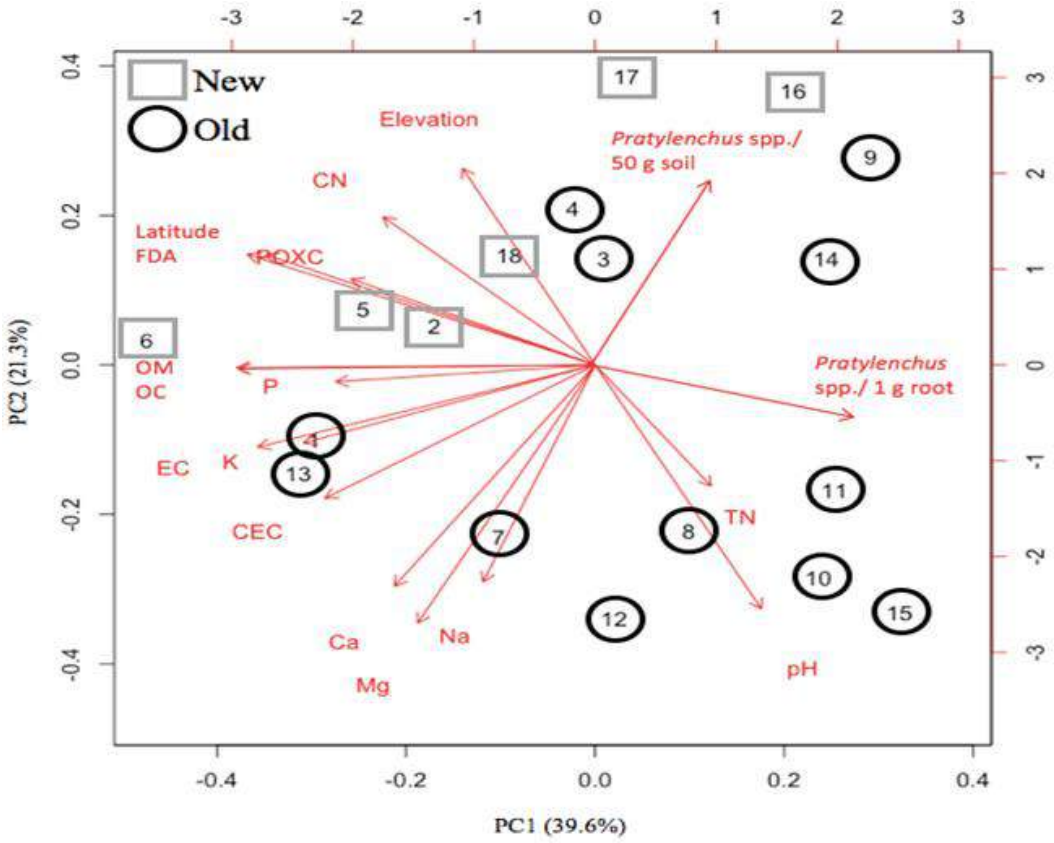
- In soil from “old” orchards, growth was typically improved by sterilizing.
- In newly cultivated soils sterilization reduced plant growth.
- Microbial activity (FDA hydrolysis) was 1.8-fold higher in new orchard soils
- Colonization of roots by the plant parasitic nematode, *Pratylenchus* spp. was 4 fold lower in new orchard soils



Paige Munro

PCA Ordination of Abiotic and Biotic Soil Variables and Topographic Variables for 18 Sites

- New orchards were clustered in the upper left quadrant
- Step-wise regression was used to identify which properties best described the variation in data
- Soil microbial activity, total organic carbon, and sodium were positive predictors of shoot height
- Calcium and magnesium were negative predictors of plant height



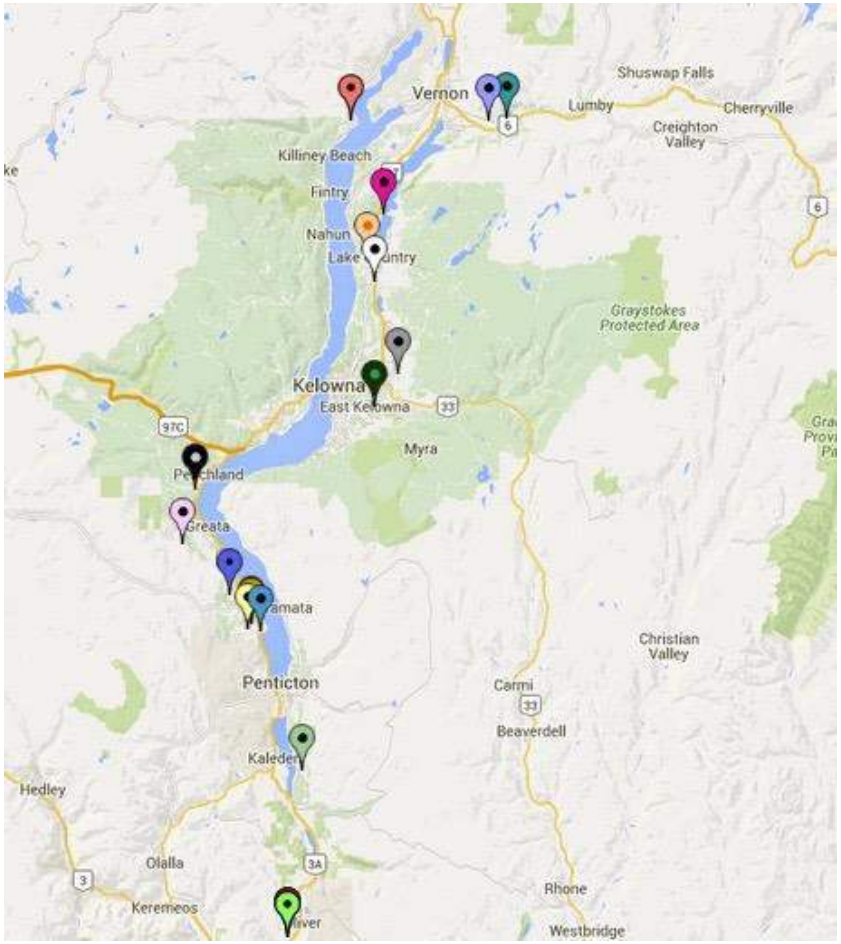
Conclusion

- New orchard soils were more biologically suitable for planting sweet cherry than old orchard soils
- The lower plant growth observed in old orchard soils may have resulted from changes in the microbial community rather than abiotic properties
- Orchard management practices that maintain organic carbon levels and stimulate an active microbial community will benefit growth of cherry trees in both new and established orchards

Short-term Objectives

To optimize water use in cherry orchards established in more northern and higher elevations sites

- Field trials established at 4 sites
  - Two newly planted orchards, N. Okanagan
  - Two established orchards, Central and S. Okanagan
- Three Orchard Floor Treatments
  - Bare soil
  - Mulch
  - Compost
- Two Irrigation Treatments
  - Current practice (Drip/microsprinkler)
  - Postharvest deficit (25% reduction)
- Measurements taken over two-three years



Organic Amendments

- **Compost**
  - Municipal yard waste
  - City of Kelowna
- **Mulch**
  - Douglas Fir wood chip
  - Local sawmill
- Surface applied to 0.05 m depth

Plant and Soil Variables Assessed

Stem water potential

Nutrient analysis

Water use efficiency

Fruit quality:

- Soluble solids
- Fruit firmness
- Titratable acidity
- Colour

Trunk cross sectional area (TCSA)

Plant roots:

- Root nematodes
- Colonization by Arbuscular mycorrhizal fungi

Soil samples:

- Nematodes
- Physicochemical properties
- Microbial activity
- Total fungi and bacteria

Effect of Organic Soil Amendments on Abiotic Soil Properties

Amendment	CEC (meq/100 g soil)	P (mg/kg)	Total N (%)	Total C (%)	Organic Matter (%)	pH
Bare	19.9 b	150 b	0.3 b	3.9 b	7.0 b	6.3 b
Compost	22.4 a	203 a	0.4 a	4.8 a	8.4 a	6.7 a
Mulch	17.6 b	148 b	0.3 b	4.1 ab	7.2 b	6.4 b
P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

- Data averaged over two years and three sites (2 newly cultivated and one established orchard)
- Compost amendment increased soil CEC, P, total %N, total %C, organic matter and pH
- Compost amendment also increased soil Ca, K, Mg, Na^+ (data not shown)

Effect of Organic Soil Amendments on Soil Biotic Properties

Amendment	% AMF Colonization	*Pratylenchus* spp. g^{-1} root	FDA Hydrolysis ug g^{-1}
Bare	27.9 a	133 a	3.7
Compost	21.3 b	103 b	4.1
Mulch	22.6 b	161 a	4.4
P value	<0.001	0.05	0.5

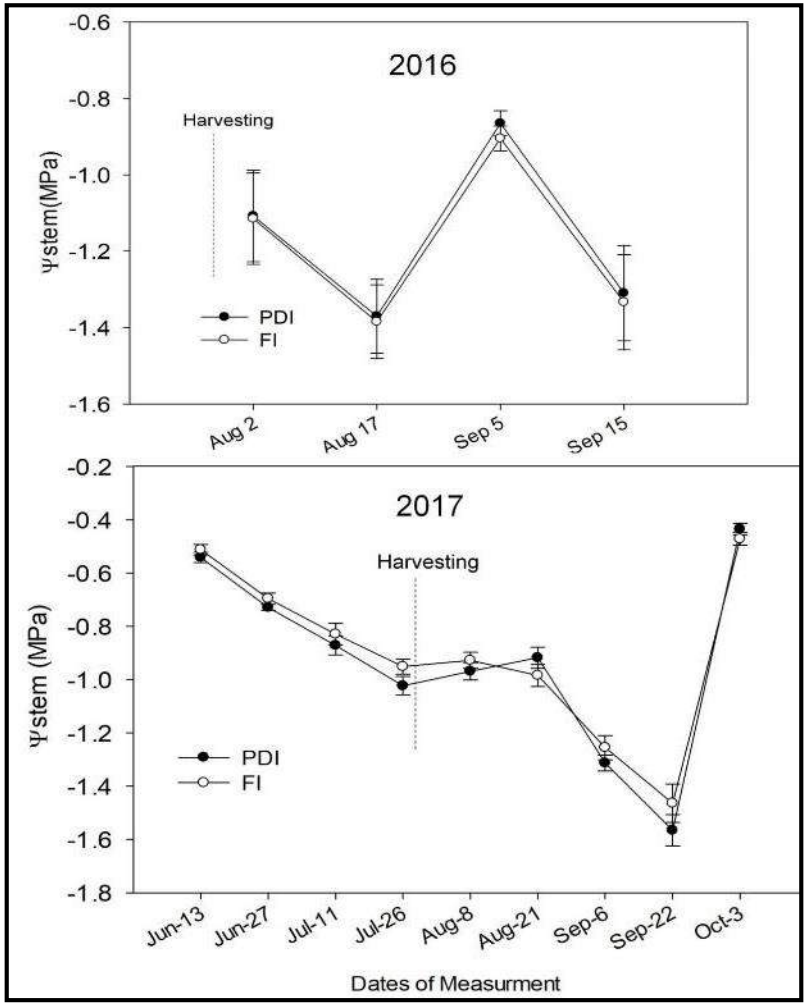
- Data averaged over two years and three sites (2 newly cultivated and one established orchard
- **Organic amendments**
  - decreased AMF colonization
  - decreased root colonization by plant parasitic nematodes
  - had no effect on soil microbial activity

Effect of Organic Soil Amendments on Fruit Yield and Quality

Treatment	Yield kg	Firmness g/mm	Stem Pull Force kg	Colour	Soluble Solids %	Titratable Acidity
New Orchard						
Compost	26.4	477 ab	0.85	3.99 a	22.1	5.95
Mulch	27.0	465 b	0.80	3.99 a	22.4	5.93
Bare	25.5	489 a	0.85	3.58 b	22.0	5.78
P value	NS	<0.05	NS	<0.001	NS	NS
Old Orchard						
Compost	8.4	423 ab	0.88	3.82	21.0 b	5.91
Mulch	6.7	395 b	0.83	3.92	21.9 a	6.10
Bare	7.2	410 ab	0.77	3.86	21.0 b	5.72
P value	NS	<0.05	NS	NS	<0.05	NS

Effect of Postharvest Deficit Irrigation

- Reducing irrigation by 25% postharvest did not affect stem water potential (a measure of plant water stress)
- Tree growth (trunk cross sectional area) and leaf area were also not affected (data not shown)



Tirhas Gebretsadikan

No Effect of Postharvest Deficit Irrigation on Fruit Yield and Quality

Treatment	Yield kg	Firmness g/mm	Stem Pull Force kg	Colour	Soluble Solids %	Titratable Acidity
New Orchard						
Full	27.5	484	0.84	3.83	21.8	5.81
Deficit	25.2	470	0.84	3.89	22.5	5.96
P value	NS	NS	NS	NS	NS	NS
Old Orchard						
Full	8.5	411	0.82	3.92	21.5	6.04
Deficit	6.4	408	0.83	3.81	21.1	5.78
P value	NS	NS	NS	NS	NS	NS

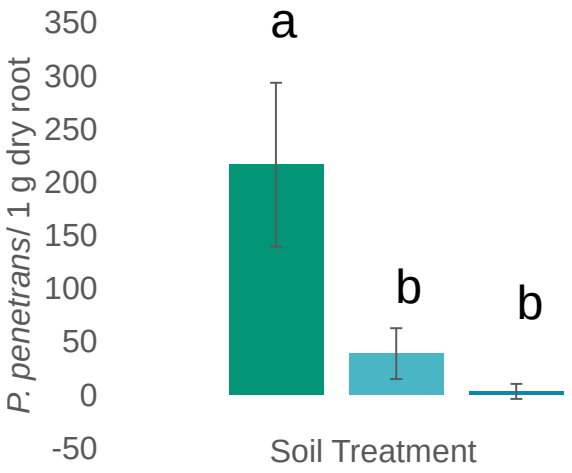
Short-term Objectives

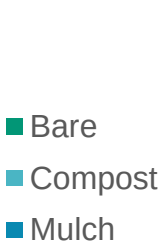
To enhance the natural biological buffering capacity of soils in cherry orchards newly planted on non-fumigated soils

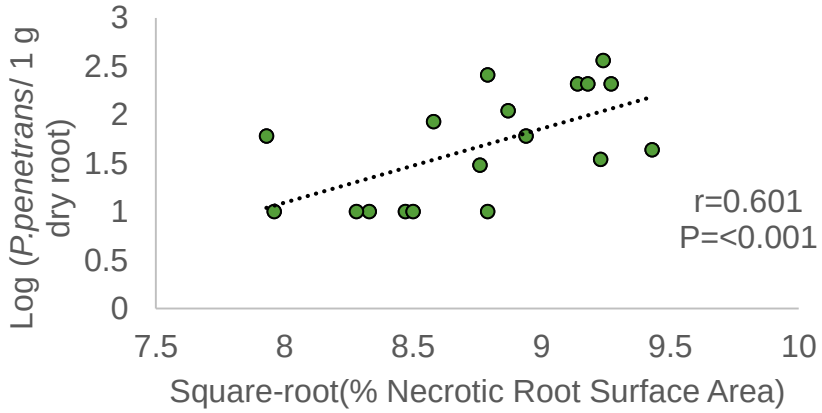
- To determine the effect of orchard floor treatments at the 3 field sites (2 new and 1 old established orchard) on soil health and plant growth, a greenhouse bioassay was set up
- Field soil from each treatment and each site was collected and sterilized or left untreated, placed in pots, planted with sour cherry explants and grown for 10 weeks
- There were no effects of soil amendment or sterilization on plant growth across the three sites

Effect of Soil Amendments on Nematode Abundance in Greenhouse Bioassay

- Compost and mulch treatments reduced abundance of plant parasitic nematodes in roots and soil
- *Pratylenchus* abundance on roots was positively correlated with % necrotic root surface area
- Suggests potential of organic amendments to reduce pathogens associated with replant disease







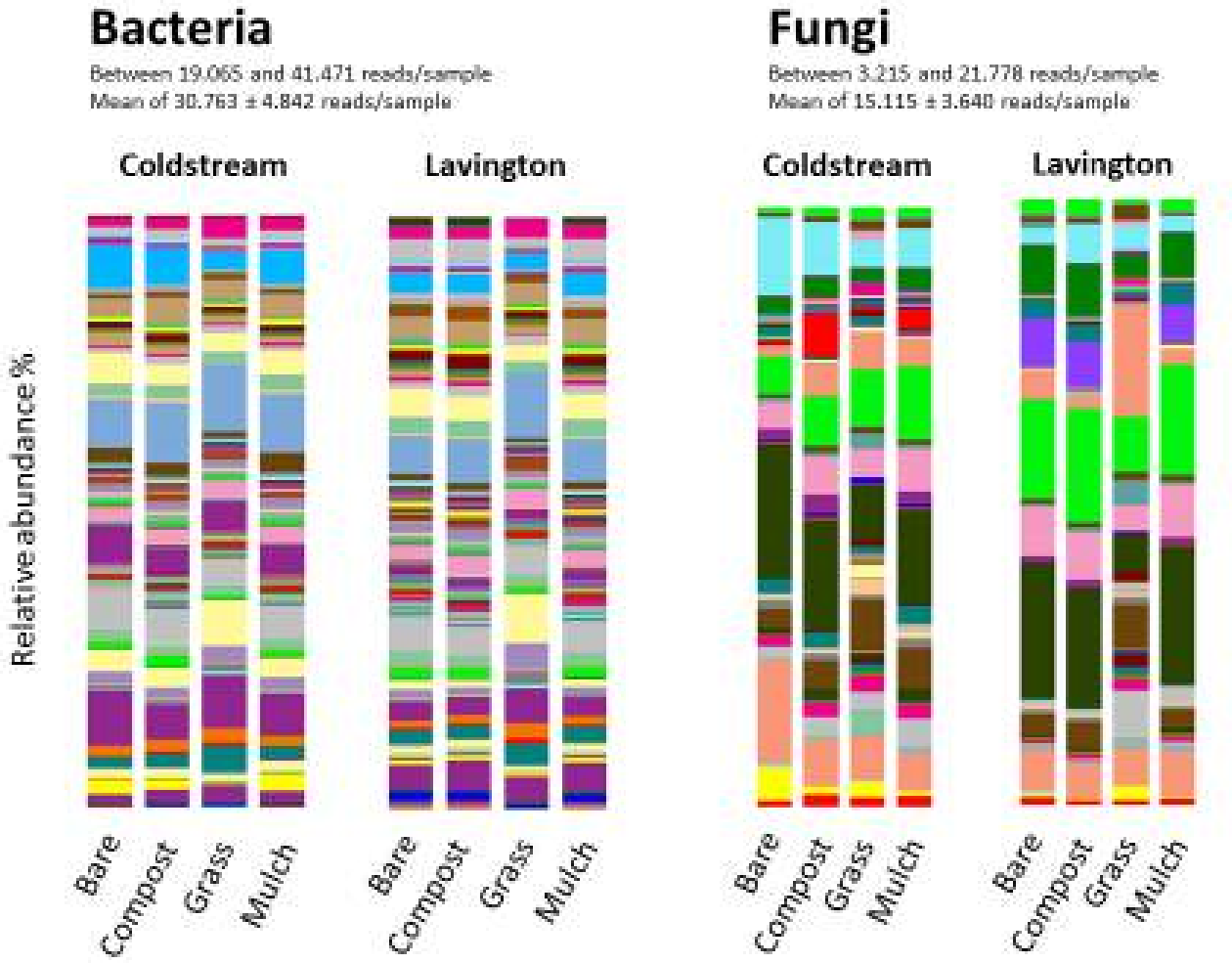
New orchard

Paige Munro

Soil Microbial Diversity

NGS Sequencing (Oct 2016 sample)

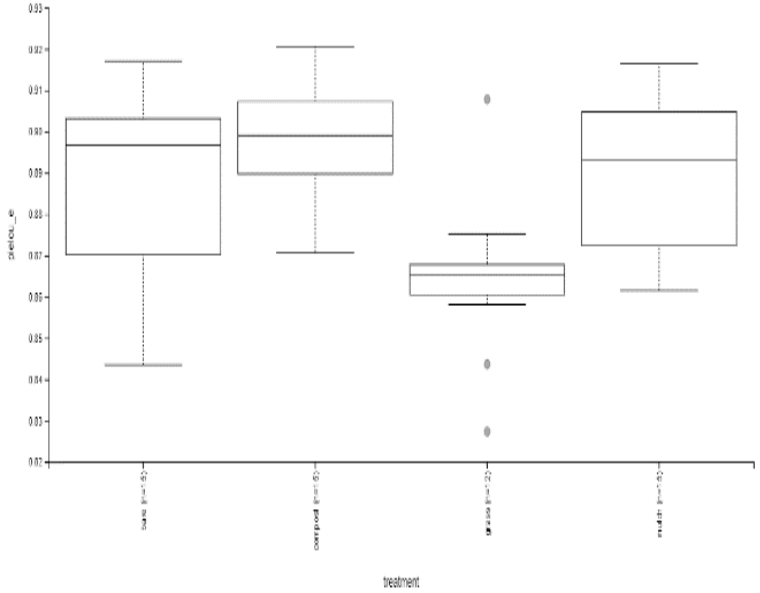
Microbial diversity differs under different organic amendment treatments



Tanja Voegel

Effect of Organic Soil Amendments on Bacterial Diversity

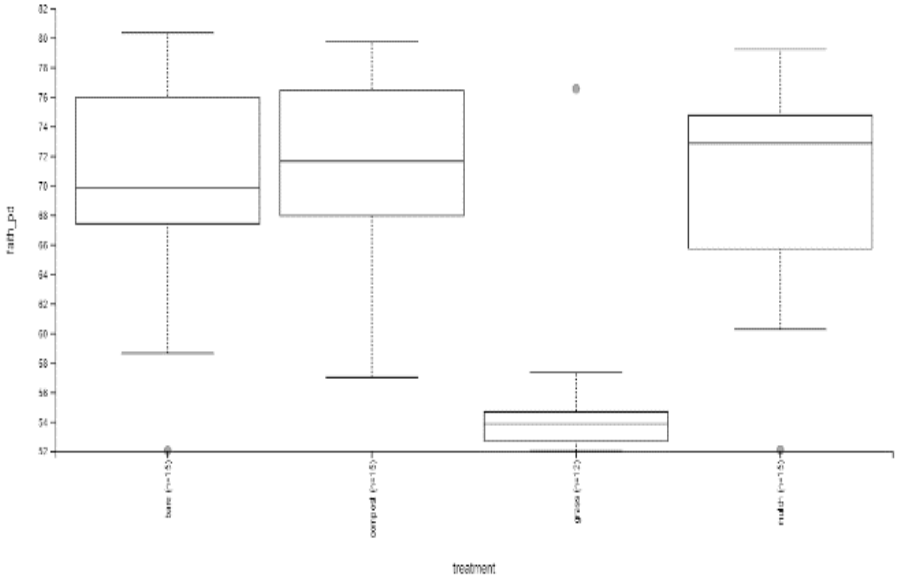
Species Evenness*



Bare Compost Grass Mulch

*Relative abundance of each species in an area

Species Richness+

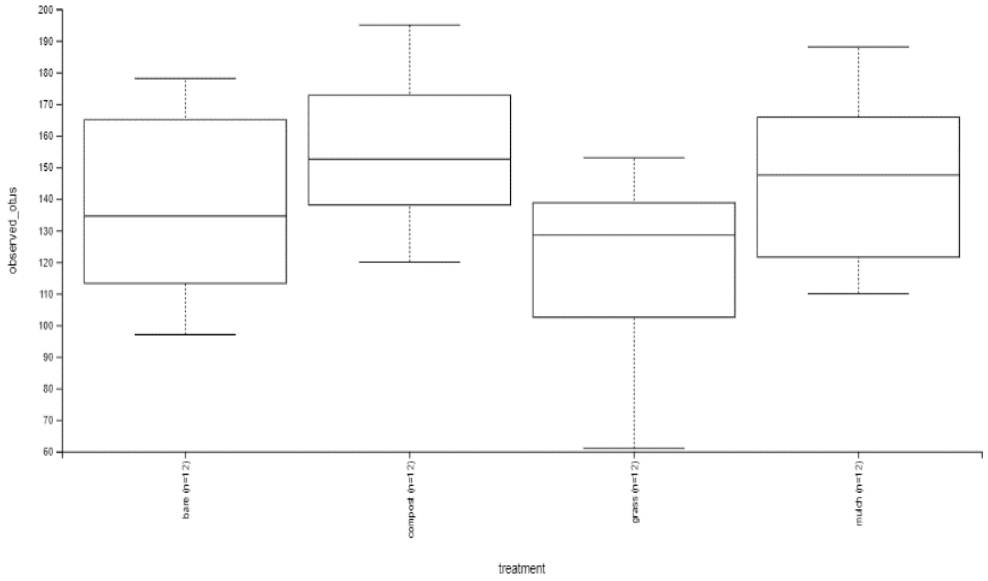


Bare Compost Grass Mulch

+ Relative phylogenetic diversity of species in an area

Effect of Organic Soil Amendments on Fungal Diversity

Species Richness



Bare Compost Grass Mulch

Overall Conclusions

- In Okanagan Cherry orchards in short-term studies
- Organic amendments such as compost and mulch show potential to:
  - Maintain soil health in newly-planted and established orchards
  - Decrease plant parasitic nematodes in soil and roots
  - Increase soil organic carbon
- Application of postharvest deficit irrigation (25% reduction):
  - Had no impact on plant water stress
  - Maintained cherry fruit quality and yield in the following year
- Limitations:
  - Longer-term monitoring needed

Practical Applications

- Our research suggests that organic amendments have potential to maintain soil health in newly-planted orchards and to restore soil health in old orchards
- Postharvest deficit irrigation can reduce water use without affecting tree health, fruit quality and yield
- The economic and social cost/benefits of these approaches are being evaluated by Dr. Julien Picault, Economist, UBC Okanagan

Future Research

- What is the impact of greater reduction in postharvest irrigation (e.g. > 25% reduction) on tree and soil health and fruit production?
- Applicability to other perennial fruit crop and wine grape production?
- Need for integrated approach with soil, agronomy and plant pathology experts
- Need for longer-term monitoring trials

Thank you to:

- Private Foundation
- BC Farm Adaption Innovator Program

Growing Forward 2
A federal-provincial-territorial initiative

Investment Agriculture Foundation of British Columbia

BCAC

Climate Action Initiative
BC AGRICULTURE & FOOD

British Columbia

Canada

- AAFC Summerland Research and Development Centre
- Dendy Orchards
- Coral Beach Farms
- 9 other growers

City of Kelowna

BC TREE FRUITS

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